Non-indigenous Fish Management Information
Fisheries Division – 2005

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There are presently 209 known, non-indigenous plants and animals that have been introduced into the Great Lakes basin between 1800 and 1999, of which 77% (162) are aquatic species (Mills et al. 1993). Routes of entry into the Great Lakes basin include canals and diversions, fish stocking programs, private aquaculture, the bait industry, recreational boating, ballast water from the shipping industry, the live food fish industry, the ornamental pond/aquarium trade, intentional and unintentional releases, and unknown sources. A recent study in Ontario found that the greatest potential pathways for future introduction and spread of invasive aquatic species are associated with ballast water from the shipping industry, the live food fish industry, and the ornamental pond/aquarium trade (Kerr et al. 2005).

The introduction or invasion of exotic species can result in significant changes that usually affect the entire Great Lakes basin. Non-indigenous species that have been present for many years in our lakes include alewife, sea lamprey, common carp, goldfish, and rainbow smelt. These species have caused significant changes in both Great lakes and inland lake aquatic communities.

Species that presently are invading many Great Lakes and inland lake systems include zebra mussels, curly-leaf pondweed, Eurasian water-milfoil, purple loosestrife, giant reed, gobies, Eurasian ruffe, various micro-invertebrate zooplankton (*Bythotrephes cederstroemi*, *Cercopagis pengoi*, *Daphnia lumholtzi*), and rusty crayfish.

DNR non-indigenous species regulations

The Department of Natural Resources has the authority to regulate stocking of spawn, fry, or fish into public waters under Act 451, Part 487. The Department also has the authority to regulate the importation of game fish and eggs under Act 451, Parts 459 and 487. The importation of Japanese weatherfish (Misgumus auguillicaudatus), grass carp (Ctenopharyngodon idellus), ide (Leuciscus idus), rudd (Cardinius erythrophthalamus), bitterling (Rodeus sericeus), tench (Tinca tinca), and species in the Salmonidae Family are prohibited without permit, under Department of Natural Resources Administrative Rules R299.1051 et seq.

Under Fisheries Order – 209.03 the Director of the Department of Natural Resources on February 7, 2003, ordered that no person shall possess or transport live Eurasian ruffe

Gymnocephalus cernuus, tubenose goby *Proterorhinus marmoratus*, round goby *Neogobius melanostromus*, black carp *Mylopharyngodon piceus*, bighead carp *Hypophthalmichtys nobilis*, silver carp *Hypophthalmichtys molitrix*, and all members of the snakehead family *Channidae*, genus *Channa*. No person shall possess or transport the eggs of any of the above species.

Under Fisheries Order – 227.04a: It shall be unlawful for any person to take, possess or sell rusty crayfish (*Orconectes rusticus*) anywhere in the State of Michigan for commercial purposes.

Management

Non-indigenous fishery issues are a common problem throughout the United States as well as the rest of the world. The American Fisheries Society is a recognized international organization of fisheries professionals. The American Fisheries Society has several Resource Policies dealing with invasive species, including Introduction of Aquatic Species (#15), Ballast Water Introductions (#24), and Responsible Use of Fish and Other Aquatic Organisms (#30; www.fisheries.org). These policies generally encompass guidelines for protecting ecological integrity and sustaining natural resources for future generations. The Michigan Department of Natural Resources has similar goals.

Michigan fishery managers have had to deal with non-indigenous species for many years. Introductions of fish into Michigan waters began as early as 1873 (Latta 1974). Smith (1970) stated that the invasion of aquatic species of fish into the Great Lakes was virtually uncontrolled at that time. More than 1/3 of all exotic species invasions into the Great Lakes have occurred in the last half of the 20th century, coinciding with the expansion of the St. Lawrence Seaway in 1959, which allowed greater transoceanic shipping traffic (Harrison 2003). Presently, there are 26 species of non-indigenous fish found in Michigan (Michigan DNR 2002).

Non-indigenous species that are successful in establishing populations are usually impossible to eradicate, and difficult and costly to control. The common carp is a good example of a species that could not be eradicated. The common carp was introduced into the United States in 1831, and into Michigan in 1879. They are still present throughout Michigan. Attempts to eradicate this species even from small inland lakes using whole lake treatments with chemicals most often failed. Failures resulted from the ability of the fish to tolerate the chemical, escape treatments areas, or reestablish again from other areas. The rusty crayfish has completely eradicated native crayfish populations from some Michigan lakes and rivers. Control this species has not been attempted in Michigan.

Management scenarios for non-indigenous species are dependent on a number of factors including ecosystem effects, methods available for control, costs, and benefits. Two examples are provided below that briefly describe management experience with invasive fish species in Michigan. The first example is for sea lamprey and alewife, which have

been present in the Great Lakes for over 50 years. Management of alewife population levels has been effective by controlling the sea lamprey population (because they affect predator abundance), stocking predators, and restoring spawning habitat for Great Lakes fish. The second example is for round goby, a species that has been present in the Great Lakes for about 15 years. This fish has recently increased dramatically in Lake Michigan, triggering requests from some anglers to implement predator (yellow perch and walleye) stocking programs. Principle concerns apparently are that round goby are affecting recruitment of yellow perch and walleye in the Lake Michigan system. The effects of round goby on Great Lakes fish communities is fairly well documented from Lake Erie, Lake St. Clair, and Lake Huron and this information is discussed below.

Sea lamprey and alewife

The sea lamprey gained access to the upper Great Lakes through the Welland Canal, which was opened in 1829 to allow ships to bypass Niagra Falls (Smith 1970). Sea lampreys were first found in Lake Erie in 1921, in Lake Huron in 1932, in Lake Michigan in 1936, and Lake Superior in 1946. The alewife was apparently accidentally introduced into Lake Ontario about 1870. They reached Lake Erie by 1931, Lake Huron in 1933, Lake Michigan in 1949, and Lake Superior in 1954.

The effects of these two species, in combination with habitat changes and selective exploitation, resulted in unprecedented ecological changes in the Great Lakes by the 1960s. Predator populations (lake trout, burbot, walleye, and yellow perch) in Lake Michigan severely declined due to lamprey predation. Reduced predator abundance allowed alewives to become very abundant. Nearly all other species of fish were also affected, especially the whitefish family. Annual natural mortalities of alewives became so excessive that Great Lakes beaches were not useable, severely affecting recreation and tourism. Management efforts to reduce lamprey numbers and stock predators (trout and salmon) have been effective at reducing population levels of alewives. The main diet of trout and salmon is principally alewives.

Controlling alewife populations requires continuous research and management activities, requires funding, and must be coordinated among all states and provinces bordering the lakes. Great Lakes biological communities are complex and setbacks have occurred like the 1986 decline in Lake Michigan chinook salmon and a similar decline in Lake Huron salmon in 2004. These declines resulted from over-stocking trout and salmon and/or low alewife recruitment.

Similarly, control of sea lamprey is extremely costly, requires interagency coordination, and is not without setbacks. In 2004, GLFC / USFWS spent more than $10 million in sea lamprey control, and (collectively) Great Lakes agencies have spent billions of dollars in control and monitoring efforts since the early 1960s. Despite these efforts, sea lamprey numbers have increased in Lake Michigan in recent years, primarily as a result of lampreys invading new spawning areas above barriers on the Manistique River.

Presently, the basic management strategy is to maintain relatively stable alewife populations and adjust trout and salmon stocking levels as needed. Overstocking predators can result in widely fluctuating levels of both predators and alewives.

Round Goby

Another more recent invader into the Great Lakes is the round goby. The round goby is a bottom oriented species that originates from Europe (Black and Caspian Seas). This is a very prolific species that prefers rocky substrate. Round goby are very aggressive and can be a nuisance to anglers when fishing for other species.

Round goby were first discovered in the St. Clair River in 1990 (Jude et al. 1992), and became established in the central basin of Lake Erie in 1994 (Lake Erie Forage Task Group 2002). In Lake Erie, round goby were well established by 1996 in the central basin, by 1997 in the western basin, and they continued to expand through 2001 in the eastern basin. Population densities increased significantly, then stabilized or declined to some extent in portions of Lake Erie by 2001 (Figures 1 & 2). Higher densities can occur in areas of the lake with rocky substrate where samples are difficult to collect. Despite the high densities of round goby, good year classes of yellow perch and walleye have been produced. Yellow perch population numbers have increased since 1994 (Figure 3). Predator species are using goby as a food item including lake trout, burbot, walleye, yellow perch and white perch (B. Haas, MDNR, personal communication).

In Lake St. Clair, round goby densities increased from 1996 to very high densities in 2001 (Figure 4). They appear to be stabilizing in some areas of the lake. The abundance of forage species remains high. The 1999 year-class of yellow perch was relatively strong in Lake St. Clair and juvenile yellow perch are presently at high levels. Walleye fishing continues to be good (Thomas and Haas 2004). Round goby in Lake St. Clair and the St. Clair River were found to feed predominantly on zebra mussels and other invertebrates (Thomas 1997). Fish formed only a trace component of the diet.

Round goby first appeared in fisheries samples in Saginaw Bay, Lake Huron in 1999 (Fielder and Thomas 2004). Their numbers increased rapidly but leveled in 2002 and declined in 2003 (Figure 5). The abundance of other forage species remains at high levels. The two strongest year-classes of yellow perch and walleye ever measured occurred in 2003, and relatively strong year-classes of these two species were also produced in 2004 (D. Fielder, MDNR, personal communication). The strong year-class strength of yellow perch and walleye was related to a significant decline in Lake Huron alewife populations. Alewives are considered to significantly (negatively) affect the abundance of juvenile fish in the Great Lakes. Predators found to be using round goby as a part of their diet in Saginaw Bay were channel catfish, walleye, yellow perch, and freshwater drum.

Round gobies were first collected in Lake Michigan at Grand Haven in 1997 (Clapp et al. 2001). It is likely that gobies were present here prior to this because adult gobies were

collected by anglers in rocky areas not accessible to sampling gear. Round gobies were also collected at Muskegon and Grand Haven in 1999. They were first collected in surveys at Escanaba in 1998. Presence was also established at Charlevoix (1998) and Kipling (1998) from angler reports. Gobies were not collected at 5 other Lake Michigan ports between 1995 and 1999. Round gobies increased in abundance in Lake Michigan at Grand Haven from 1997 (0.0-0.5 fish/h) through 2002, then decrease in 2004 (38.0-69.0 fish/h; Clapp et al. 2001; Figure 6). They were collected in surveys at Escanaba at a rate of 7.5 fish/h. Yellow perch density declined in Lake Michigan beginning around 1990, and moderate to strong year-classes were produced in 1998, 2002, and 2003 (Clapp and Dettmers 2004; Clapp 2004; Figure 7). Investigations of the Lake Michigan Yellow Perch Task Group indicate one of the principal factors in determining recruitment of yellow perch are zooplankton abundance and composition. A myriad of weather and limnological factors affect zooplankton abundance, and zebra mussels and alewife probably also have significant indirect effects. Walleye populations in Lake Michigan suffered significant declines during the 1960s, also related to alewife invasions. Walleye population numbers have increased substantially as a result of stocking programs and alewife reductions. Recruitment of walleye continues to be a problem, and is likely affected by the presence of alewife. Preliminary findings of ongoing diet studies indicate round gobies form a portion of Lake Michigan lake trout diet (Jory Jonas, MDNR, personal communication). Ongoing diet studies (2004 and 2005) of walleye in Muskegon Lake have not found the presence of round goby (Christine Diana, University of Michigan, personal communication).

In summary of the information available on round goby, the following points can be made.

1) Round goby are a very prolific species that prefers rocky substrates. They have been present in the upper Great Lakes since 1990, and are now found in all of the upper Great Lakes.

2) Once established this species reaches very high abundance, and then declines as habitat becomes saturated and competitive and predatory interactions of the biological community develop. This is typical of prolific exotic species. Observations from all lakes from Lake Erie to Lake Michigan indicate that predators are increasingly using round goby as prey species as time progresses. These lakes are shallow, very productive systems that have very high predator densities. These high predator densities are likely affecting goby abundance, but abundance remains high and eradication of gobies is not expected. Round gobies feed on zebra mussels and provide a benefit in converting this exotic species into a food source for native fishes.

3) The presence of round goby in all lakes from Lake Erie to Lake Michigan does not significantly inhibit the recruitment of walleye and yellow perch. Some of the strongest annual recruitment has been recorded for walleye and yellow perch in the presence of very high densities of round goby. Population levels and fishing

for walleye and yellow perch are within expected limits in these lakes. Alewives significantly affect recruitment of walleye and yellow perch.

Round goby apparently entered Lake Michigan several years later than Lake Erie, Lake St. Clair, and Lake Huron. The abundance of gobies has recently begun to reach high levels. This has caused concern among anglers because of the possibility of effects on game fish species and they can be a nuisance. It should be noted that anglers in the other Great Lakes continue to enjoy good fishing in the presence of abundant goby populations.

The goby invasion has resulted in requests to the Michigan DNR to increase walleye stocking and begin yellow perch stocking in Lake Michigan and adjoining waters. Changing the management programs of these two species is not recommended as a result of the round goby invasion into Lake Michigan. Presently, Fisheries Division stocks significant numbers of walleye in Muskegon Lake (historical population) and other adjoining lakes suitable to saturate available habitat for this species. Yellow perch population levels in the drowned river mouth lakes (Muskegon Lake, White Lake, and Mona Lake) are at sufficient levels, and main basin stocks are rebuilding as a result of cooperative management efforts. Yellow perch stocking into Lake Michigan is discouraged and against policies established by Michigan and the other bordering states and provinces (Lake Michigan Committee). Yellow perch (and walleye) recruitment does not appear to be limited by round goby populations, as indicated by information from numerous Great Lakes studies. Lake Michigan natural recruitment of yellow perch and population levels have fluctuated widely in the past (Makauskas and Allan 2004; Wilberg et al. 2004) and it is anticipated stronger year-classes will occur in the future. A stocking program for yellow perch in Lake Michigan would be extremely large, complex, and expensive, with questionable results (strong year-classes produced in 1998 and 2002).

The salmon and trout stocking program in Lake Michigan encompasses a very large, multi-agency effort necessary to control alewife populations. Alewives affect almost every species of fish in Lake Michigan because they feed on zooplankton, as well as larval fish. Stocking of salmon and trout is necessary because natural recruitment is not sufficient to support populations. Efforts to improve recruitment are ongoing in the form of habitat restoration.

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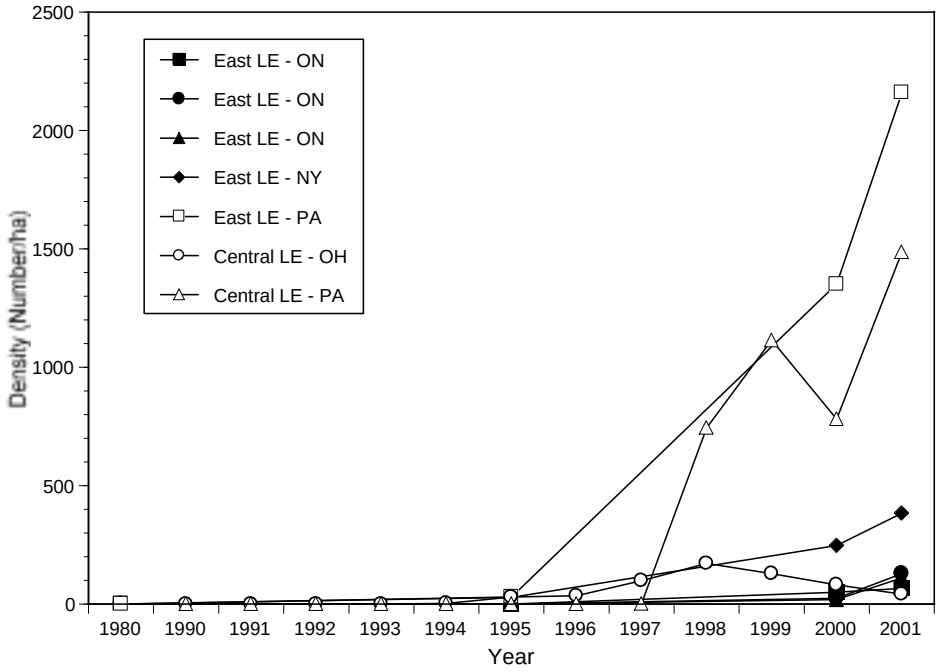

Figure 1. Density estimates of young-of-the-year round goby from various sampling sites in central and eastern Lake Erie (LE). ON=Ontario, NY=New York, PA=Pennsylvania, OH=Ohio. Information obtained from Lake Erie Forage Task Force (2002).

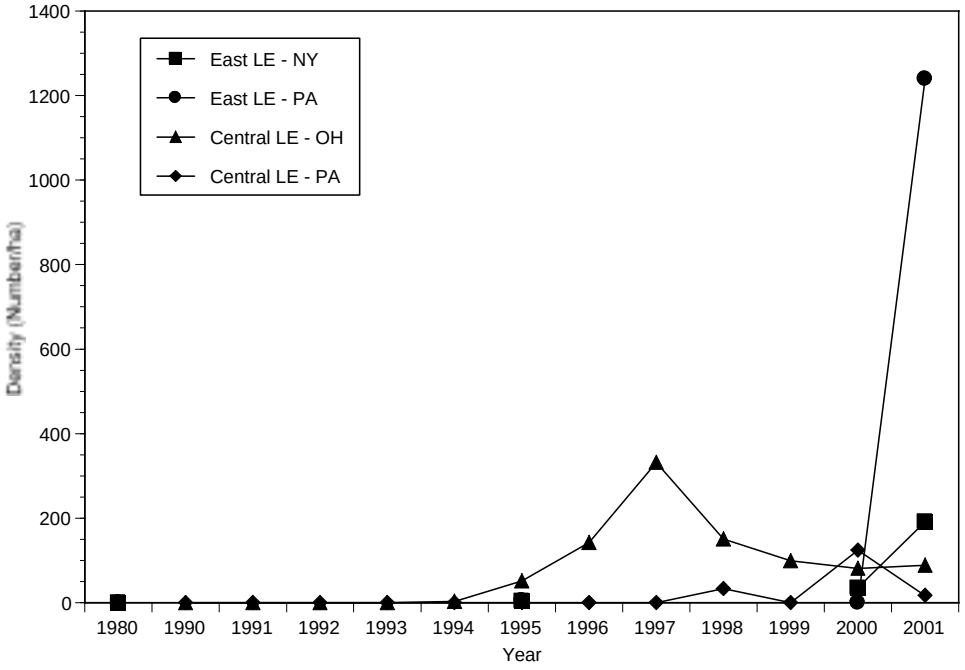

Figure 2. Density estimates of yearling-and-older round goby from various sampling sites in central and eastern Lake Erie (LE). NY=New York, PA=Pennsylvania, OH=Ohio. Information obtained from Lake Erie Forage Task Force (2002).

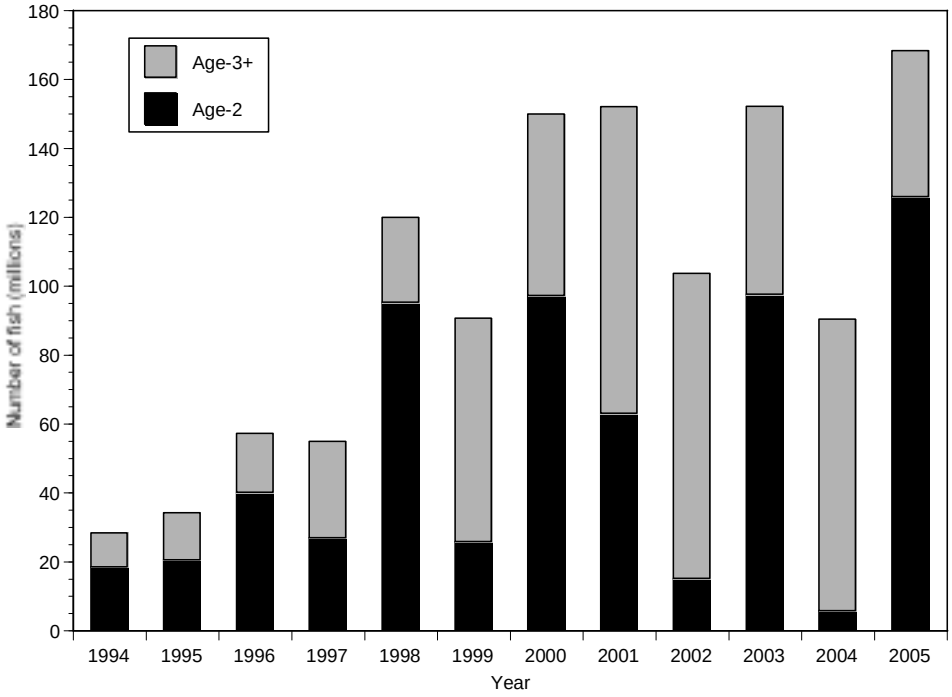

Figure 3. Lake Erie yellow perch population estimates for age-2 and age-3+ fish. Information obtained from Lake Erie Yellow Perch Task Group (2005).

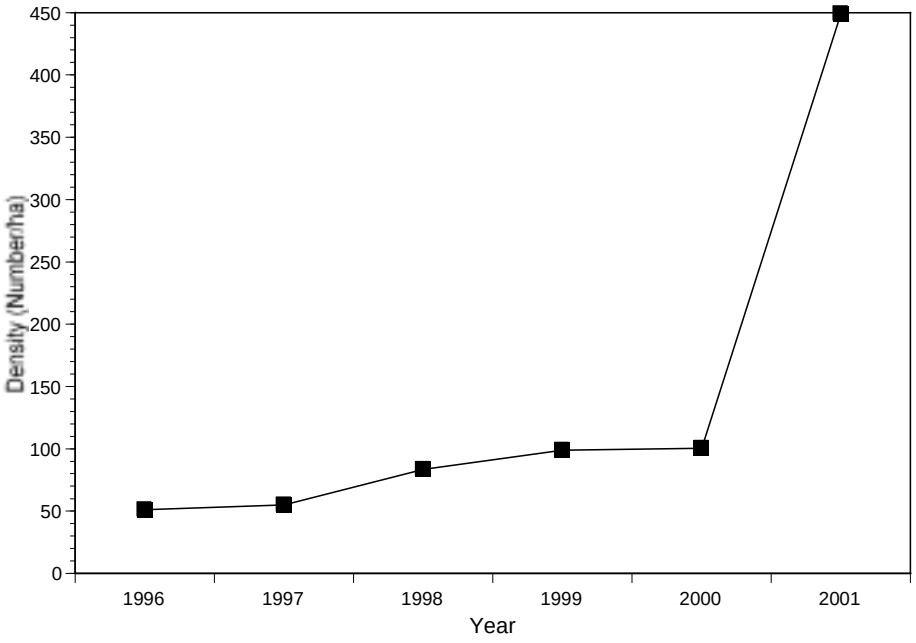

Figure 4. Density estimates of round goby in Lake St. Clair, 1996-2001. Information obtained from Lake Erie Forage Task Force (2002).

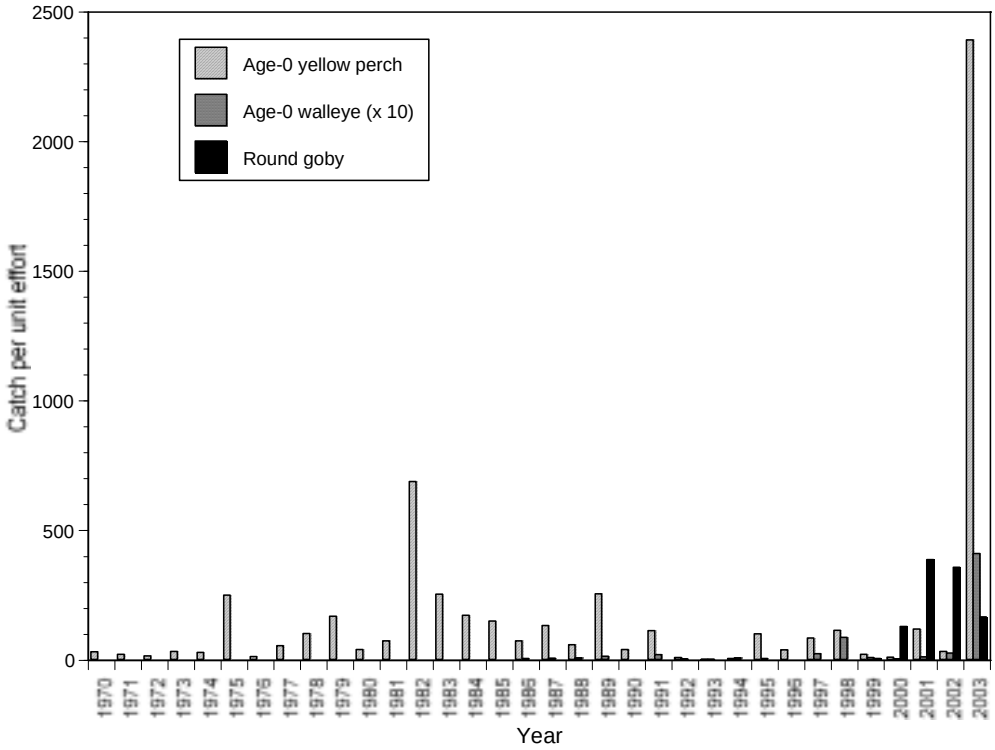

Figure 5. Mean bottom trawl catch-per-unit effort for age-0 yellow perch, age-0 walleye (times 10), and round goby from Saginaw Bay, Lake Huron. Information obtained from Fielder and Thomas (2004).

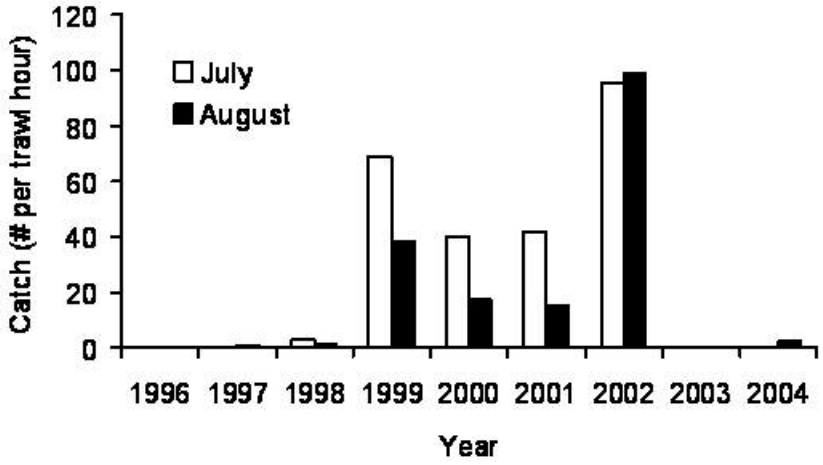

Figure 6. Round goby abundance based on trawling at Grand Haven, Michigan. Samples were not collected in 2003 (Michigan DNR survey records).

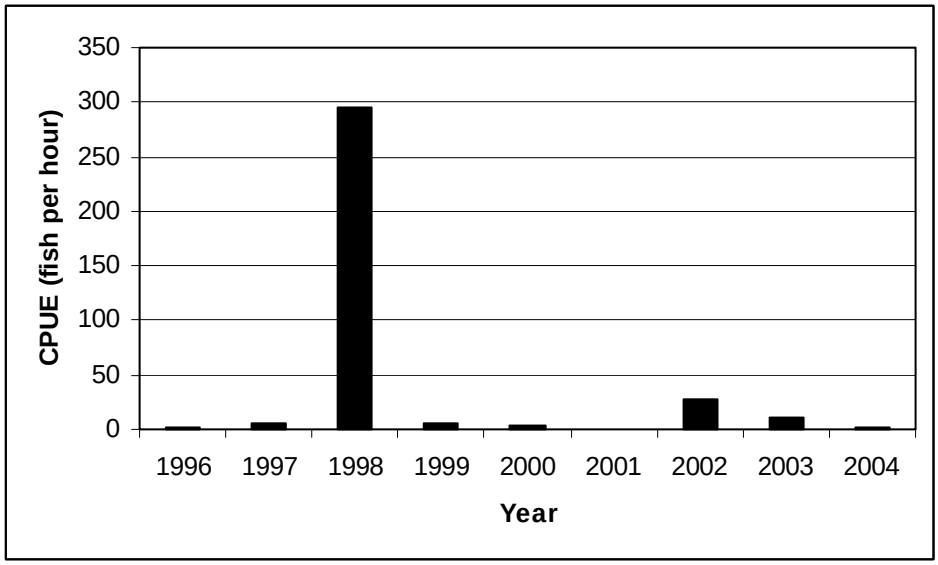

Figure 7. Yellow perch year-class strength (age-0 abundance) based on trawling at South Haven, Michigan (Michigan DNR survey records).